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| <b>(54) Title:</b> VACCINE ADJUVANT<br><br><b>(57) Abstract</b><br><br>An immunogen/vaccine adjuvant composition containing an immunogen in an amount effective to stimulate an immune response and as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune response to the immunogen.   |           |   |

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VACCINE ADJUVANTField of the Invention

This invention relates to compositions comprising  
5 a vaccine and a vaccine adjuvant. In another aspect  
this invention relates to vaccine adjuvants.

Description of the Related Art

In the field of immunology it has been well known  
10 for many years that immune response to certain antigens  
which are otherwise weakly immunogenic can be enhanced  
through the use of vaccine adjuvants. Such adjuvants  
potentiate the immune response to specific antigens and  
are therefore the subject of considerable interest and  
15 study within the medical community.

A wealth of knowledge concerning the complexity  
and sophistication of immune regulation  
("immunomodulation") has become available in the past  
decade. Coupled with currently available biosynthetic  
20 and recombinant DNA technology, this knowledge is  
permitting development of vaccines possessing antigenic  
epitopes that were previously impossible to produce.  
For example, currently available vaccine candidates  
include synthetic peptides mimicking streptococcal,  
25 gonococcal, and malarial antigens. These purified  
antigens are generally weak immunogens, however, that  
require adjuvants in order to evoke protective  
immunity. Unfortunately, however, as detailed below,  
conventional vaccine adjuvants possess a number of  
30 drawbacks which limit their overall use and  
effectiveness.

Over the years, Freund's complete or incomplete  
(i.e., without mycobacteria) adjuvants have been  
considered the classic adjuvants to which most other  
35 adjuvants are compared. However, clinical use of such  
adjuvants in animals or humans is precluded because  
they produce granulomas at the site of injection; fever

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and other toxic effects; and tuberculin hypersensitivity. Other materials, such as mineral oil and aluminum hydroxide, have also been used as adjuvants, but they invariably suffer from disadvantages. For example, mineral oil is known to produce tissue irritation and to be potentially oncogenic. Aluminum hydroxide, the only approved adjuvant in the United States, also induces granulomas at the inoculation site and furthermore it does not effectively induce cell mediated immunity. Moreover, many of the adjuvants currently available have limited utility because they contain components which are not metabolizable in humans. Additionally, most adjuvants are difficult to prepare in that they may require time consuming procedures and the use, in some cases, of elaborate and expensive equipment to formulate a vaccine and adjuvant system.

For a thorough discussion of various immunological adjuvants, see "Current Status of Immunological Adjuvants", Ann. Rev. Immunol., 1986, 4, pp. 369-388. See also U.S. Pat. Nos. 4,806,352; 5,026,543; and 5,026,546 for disclosures of various vaccine adjuvants appearing in the patent literature.

In recent years, in an ongoing attempt to find new adjuvants for vaccines which would overcome the drawbacks and deficiencies of conventional adjuvants, there have been those within the medical community who have postulated that the adjuvant potential of various substances can be directly correlated to their immunomodulatory capabilities, i.e., the ability to affect the immune system in some fashion. For example, increased cytokine (e.g., TNF, IL-2, IL-6, IL-8, alpha-interferon, etc.) production by a particular substance could be interpreted as being indicative of a beneficial effect if used as an adjuvant for vaccines. The latter, however, has not always been found to be true.

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Staphylococcus enterotoxin B, for example, has not been found to be immunoenhancing for either cell-mediated (e.g., cytotoxic T-cell lymphocytes) or humoral immune responses (i.e., specific antibody production) even though the enterotoxin has been shown to increase the level of production of various cytokines such as IL-2, TNF, gamma-interferon, etc. (see, e.g., J. Immunol., 1975, 115, 575 (Smith et al.) and Infection and Immunity, 1978, 22, 62 (Lansford et al.)) The same situation has been shown to be true for Toxic Shock Syndrome toxin-1 and a variety of other substances as well (see, e.g., J. Infectious Diseases, 1986, 153, 722 (Poindexter et al.), Immunology, 1986, 58, 203 (Meusen et al.), and J. Clin. Invest., 1984, 73, 1312 (Ikejima et al.)).

In view of the foregoing, it can be readily seen that the general immunomodulatory effects of various substances is not necessarily an accurate barometer of their immunoenhancing capabilities. Accordingly, this fact has frustrated the search for materials which would be effective adjuvants for various vaccines and as a result such materials are constantly sought by and are in high demand within the medical community. Clearly, an adjuvant formulation which elicits potent cell-mediated and humoral immune responses to a wide range of antigens in humans and domestic animals, but lacking the side effects of conventional adjuvants, such as Freund's complete adjuvant, would be highly desirable. It was against this background that Applicants began their search for an effective vaccine adjuvant.

#### Summary of the Invention

This invention provides an immunogen/vaccine adjuvant composition comprising an immunogen in an amount effective to stimulate an immune response and as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine

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in an amount effective to increase the immune response to the immunogen.

- This invention also provides a method of increasing the immune response to an immunogen, comprising the step of administering (i) the immunogen in an amount effective to stimulate an immune response, and (ii) as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune response.
- 10 Certain 1H-imidazo[4,5-c]quinolin-4-amines have been disclosed as antiviral agents (see, e.g., U.S. Pat. Nos. 4,689,338 (Gerster) and 4,929,624 (Gerster et al.), European Patent Application 90.301776.3 (Gerster) and commonly assigned copending U.S. patent
- 15 applications 07/838,475 (Gerster et al.), 07/754,610 (Gerster et al.), and 07/788,565 (Gerster et al.). Certain of these compounds are also known to induce biosynthesis of cytokines such as interferons, interleukins, and tumor necrosis factor in humans and
- 20 in mice. In this invention, however, the 1H-imidazo[4,5-c]quinolin-4-amine functions as a vaccine adjuvant (i.e., it is an immunostimulatory substance that potentiates humoral and/or cell mediated immune responses to an immunogen). These compounds are
- 25 relatively small synthetic organic molecules that are well characterized and substantially free of contaminants that can cause undesired effects. They are generally suitably nontoxic and do not cause undue irritation at the site of injection. Therefore this
- 30 invention avoids the shortcomings seen with some vaccine adjuvants of the prior art.

#### Detailed Description of the Invention

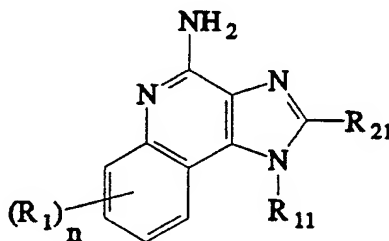
- As used herein the term "immunogen/vaccine
- 35 adjuvant composition" refers to a combination of an immunogen and a 1H-imidazo[4,5-c]quinolin-4-amine, whether that combination is in the form of an admixture

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of the two components in a pharmaceutically acceptable carrier or in the form of separate, individual components, for example in the form of a kit comprising an immunogen as one component and the 1H-imidazo[4,5-c]quinolin-4-amine as another component.

The vaccine adjuvant component of a composition of the invention is a 1H-imidazo[4,5-c]quinolin-4-amine. It has been found that compounds of this class induce biosynthesis of a variety of cytokines in human and murine cells. While the particular profile of cytokine induction varies to some extent from compound to compound within this class, it is thought that the general profile of cytokine induction common to the compounds of the class is responsible for the vaccine adjuvant activity of the compounds. Also, some compounds of this class have been shown to be potent stimulants of  $\beta$ -lymphocytes and therefore capable of increasing humoral immune response.

Preferably the 1H-imidazo[4,5-c]quinolin-4-amine is a compound defined by one of Formulas I-V below:



I

wherein

$R_{11}$  is selected from the group consisting of alkyl, hydroxyalkyl, acyloxyalkyl, benzyl, (phenyl)ethyl and phenyl, said benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently selected from

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the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms and halogen, with the proviso that if said benzene ring is substituted by two of said moieties, then said

5 moieties together contain no more than 6 carbon atoms;

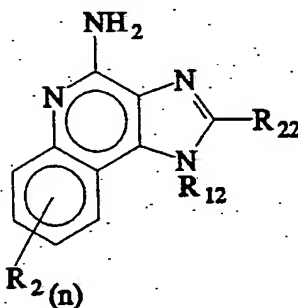
$R_{21}$  is selected from the group consisting of hydrogen, alkyl of one to about eight carbon atoms, benzyl, (phenyl)ethyl and phenyl, the benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the

10 benzene ring by one or two moieties independently selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms and halogen, with the proviso that when the benzene ring is substituted by two of said

15 moieties, then the moieties together contain no more than 6 carbon atoms; and each  $R_1$  is independently selected from the group consisting of alkoxy of one to about four carbon atoms, halogen and alkyl of one to about four carbon atoms, and  $n$  is an integer from 0 to

20 2, with the proviso that if  $n$  is 2, then said  $R_1$  groups together contain no more than 6 carbon atoms;

25



30

II

wherein

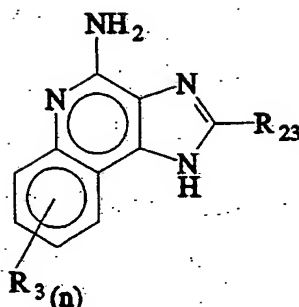
35  $R_{12}$  is selected from the group consisting of straight chain or branched chain alkenyl containing 2



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- to about 10 carbon atoms and substituted straight chain or branched chain alkenyl containing 2 to about 10 carbon atoms, wherein the substituent is selected from the group consisting of straight chain or branched chain alkyl containing 1 to about 4 carbon atoms and cycloalkyl containing 3 to about 6 carbon atoms; and cycloalkyl containing 3 to about 6 carbon atoms substituted by straight chain or branched chain alkyl containing 1 to about 4 carbon atoms; and
- 10  $R_{22}$  is selected from the group consisting of hydrogen, straight chain or branched chain alkyl containing one to about eight carbon atoms, benzyl, (phenyl)ethyl and phenyl, the benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the
- 15 benzene ring by one or two moieties independently selected from the group consisting of straight chain or branched chain alkyl containing one to about four carbon atoms, straight chain or branched chain alkoxy containing one to about four carbon atoms, and halogen,
- 20 with the proviso that when the benzene ring is substituted by two such moieties, then the moieties together contain no more than 6 carbon atoms; and
- each  $R_2$  is independently selected from the group consisting of straight chain or branched chain alkoxy
- 25 containing one to about four carbon atoms, halogen, and straight chain or branched chain alkyl containing one to about four carbon atoms, and  $n$  is an integer from zero to 2, with the proviso that if  $n$  is 2, then said  $R_2$  groups together contain no more than 6 carbon atoms;
- 30

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III

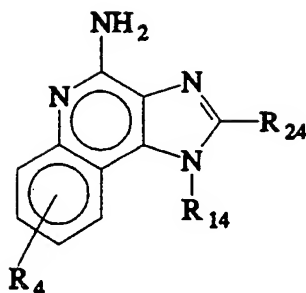
wherein

R<sub>23</sub> is selected from the group consisting of hydrogen, straight chain or branched chain alkyl of one to about eight carbon atoms, benzyl, (phenyl)ethyl and phenyl, the benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently selected from the group consisting of straight chain or branched chain alkyl of one to about four carbon atoms, straight chain or branched chain alkoxy of one to about four carbon atoms, and halogen, with the proviso that when the benzene ring is substituted by two such moieties, then the moieties together contain no more than 6 carbon atoms; and

each R<sub>3</sub> is independently selected from the group consisting of straight chain or branched chain alkoxy of one to about four carbon atoms, halogen, and straight chain or branched chain alkyl of one to about four carbon atoms, and n is an integer from zero to 2, with the proviso that if n is 2, then said R<sub>3</sub> groups together contain no more than 6 carbon atoms;

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10

## IV

wherein  $R_{14}$  is  $-\text{CHR}_A\text{R}_B$

wherein

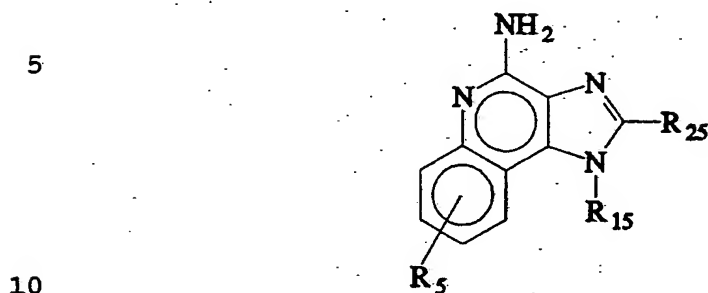
15  $R_B$  is hydrogen or a carbon-carbon bond, with the proviso that when  $R_B$  is hydrogen  $R_A$  is alkoxy of one to about four carbon atoms, hydroxyalkoxy of one to about four carbon atoms, 1-alkynyl of two to about ten carbon atoms, tetrahydropyranyl, alkoxyalkyl wherein the  
 20 alkoxy moiety contains one to about four carbon atoms and the alkyl moiety contains one to about four carbon atoms, 2-, 3-, or 4-pyridyl, and with the further proviso that when  $R_B$  is a carbon-carbon bond  $R_B$  and  $R_A$  together form a tetrahydrofuran group optionally  
 25 substituted with one or more substituents independently selected from the group consisting of hydroxy and hydroxyalkyl of one to about four carbon atoms;

$R_{24}$  is selected from the group consisting of hydrogen, alkyl of one to about four carbon atoms,  
 30 phenyl, and substituted phenyl wherein the substituent is selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen; and

$R_4$  is selected from the group consisting of  
 35 hydrogen, straight chain or branched chain alkoxy containing one to about four carbon atoms, halogen, and

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straight chain or branched chain alkyl containing one to about four carbon atoms;



V

15 wherein

$R_{15}$  is selected from the group consisting of: hydrogen; straight chain or branched chain alkyl containing one to about ten carbon atoms and substituted straight chain or branched chain alkyl containing one to about ten carbon atoms, wherein the substituent is selected from the group consisting of cycloalkyl containing three to about six carbon atoms and cycloalkyl containing three to about six carbon atoms substituted by straight chain or branched chain alkyl containing one to about four carbon atoms; straight chain or branched chain alkenyl containing two to about ten carbon atoms and substituted straight chain or branched chain alkenyl containing two to about ten carbon atoms, wherein the substituent is selected from the group consisting of cycloalkyl containing three to about six carbon atoms and cycloalkyl containing three to about six carbon atoms substituted by straight chain or branched chain alkyl containing one to about four carbon atoms; hydroxyalkyl of one to about six carbon atoms; alkoxyalkyl wherein the alkoxy moiety contains one to about four carbon atoms and the alkyl moiety contains one to about six carbon atoms;

20

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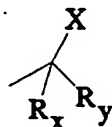
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acyloxyalkyl wherein the acyloxy moiety is alkanoyloxy of two to about four carbon atoms or benzoyloxy, and the alkyl moiety contains one to about six carbon atoms; benzyl; (phenyl)ethyl; and phenyl; said benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen, with the proviso that when said benzene ring is substituted by two of said moieties, then the moieties together contain no more than six carbon atoms;

$R_{25}$  is



20 wherein

$R_x$  and  $R_y$  are independently selected from the group consisting of hydrogen, alkyl of one to about four carbon atoms, phenyl, and substituted phenyl wherein the substituent is elected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen;

X is selected from the group consisting of alkoxy containing one to about four carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to about four carbon atoms and the alkyl moiety contains one to about four carbon atoms, haloalkyl of one to about four carbon atoms, alkylamido wherein the alkyl group contains one to about four carbon atoms, amino, substituted amino wherein the substituent is alkyl or hydroxyalkyl of one to about four carbon atoms, azido, alkylthio of one to about four carbon atoms; and

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$R_3$  is selected from the group consisting of hydrogen, straight chain or branched chain alkoxy containing one to about four carbon atoms, halogen, and straight chain or branched chain alkyl containing one  
5 to about four carbon atoms;

or a pharmaceutically acceptable salt of any of the foregoing.

The compounds recited above are disclosed and claimed in the several patents and applications noted  
10 above in the Summary of the Invention.

In instances where  $n$  can be zero, one, or two,  $n$  is preferably zero or one.

The substituents  $R_1$ - $R_5$  above are generally designated "benzo substituents" herein. The preferred  
15 benzo substituent is hydrogen.

The substituents  $R_{11}$ - $R_{15}$  above are generally designated "1-substituents" herein. The preferred 1-substituent is 2-methylpropyl or 2-hydroxy-2-methylpropyl.

20 The substituents  $R_{21}$ - $R_{25}$  above are generally designated "2-substituents" herein. The preferred 2-substituents are hydrogen, alkyl of one to about six carbon atoms, alkoxyalkyl wherein the alkoxy moiety contains one to about four carbon atoms and the alkyl  
25 moiety contains one to about four carbon atoms. Most preferably the 2-substituent is hydrogen, methyl, or ethoxymethyl.

Preferred compounds 1H-imidazo[4,5-c]quinolin-4-amines include:

30 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine;

1-(2-hydroxy-2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine; and

35 1-(2-hydroxy-2-methylpropyl)-2-methyl-1H-imidazo[4,5-c]quinolin-4-amine; and

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1-(2-hydroxy-2-methylpropyl)-2-ethoxymethyl-1H-imidazo[4,5-c]quinolin-4-amine.

The 1H-imidazo[4,5-c]quinolin-4-amine is present (or administered, as appropriate to the form of the immunogen/vaccine adjuvant composition) in an amount effective to increase the immune response to a particular immunogen. For example, in instances where the compound is administered independent of the immunogen, e.g., by separate injection, the compound is generally administered in an amount of about 0.003 to about 5 mg/kg. The particular amount that constitutes an effective amount, however, depends to some extent upon certain factors, including the particular 1H-imidazo[4,5-c]quinolin-4-amine, the particular immunogen being administered and the amount thereof, the immune response that is to be enhanced (humoral or cell mediated), the state of the immune system (e.g., suppressed, compromised, stimulated), the method and order of administration of the compound and the immunogen, the species, and the desired therapeutic result. Accordingly it is not practical to set forth generally the amount that constitutes an effective amount of the 1H-imidazo[4,5-c]quinolin-4-amine. Those of ordinary skill in the art, however, can readily determine the appropriate amount with due consideration of such factors.

As shown in the Examples that follow, a 1H-imidazo[4,5-c]quinolin-4-amine has the effect of enhancing both humoral and cell mediated immune response. Therefore the immunogen can be any material that raises either humoral or cell mediated immune response, or both. Suitable immunogens include live viral and bacterial immunogens and inactivated viral, tumor-derived, protozoal, organism-derived, fungal, and bacterial immunogens, toxoids, toxins, polysaccharides, proteins, glycoproteins, peptides, and the like. Conventional vaccine preparations, such as those used

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in connection with BCG (live bacteria), cholera, plague, and typhoid (killed bacteria), hepatitis B, influenza, inactivated polio, and rabies (inactivated virus), measles, mumps, rubella, oral polio, and yellow fever (live virus), tetanus and diphtheria (toxoids), hemophilus influenzae b, meningococcal, and pneumococcal (bacterial polysaccharides) can be used as the immunogen. Because the 1H-imidazo[4,5-c]quinolin-4-amine compounds induce biosynthesis of antiviral cytokines, in the instance of a live viral immunogen it is preferred to administer the virus prior to administration of the adjuvant compound in order that the viral infection can be established.

Furthermore, it is contemplated that certain currently experimental immunogens, especially materials such as recombinant proteins, glycoproteins, and peptides that do not raise a strong immune response, will also find use in connection with a 1H-imidazo[4,5-c]quinolin-4-amine. Exemplary experimental subunit immunogens include those related to viral disease such as adenovirus, AIDS, chicken pox, cytomegalovirus, dengue, feline leukemia, fowl plague, hepatitis A, hepatitis B, HSV-1, HSV-2, hog cholera, influenza A, influenza B, Japanese encephalitis, measles, parainfluenza, rabies, respiratory syncytial virus, rotavirus, wart, and yellow fever.

Preferred immunogens for use in this invention include T-dependent immunogens such as viral pathogens and tumor-derived immunogens.

A particular preferred immunogen for use in this invention is a herpes simplex II (HSV-2) glycoprotein subunit preparation prepared as described in J. Infect. Dis. 1987, 155, 914 (Stanberry et al.).

In the method of the invention, the immunogen is administered in an amount effective to stimulate an immune response. The amount that constitutes an effective amount depends to some extent upon certain



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factors, including the particular immunogen, the particular adjuvant being administered and the amount thereof, the immune response that is to be enhanced (humoral or cell mediated), the state of the immune system (e.g., suppressed, compromised, stimulated), the method and order of administration of the compound and the immunogen, and the desired therapeutic result. Accordingly it is not practical to set forth generally the amount that constitutes an effective amount of immunogen. Those of ordinary skill in the art, however, can readily determine the appropriate amount with due consideration of such factors.

The immunogen/vaccine adjuvant compositions of the invention can contain further pharmaceutically acceptable ingredients, excipients, carriers, and the like well known to those skilled in the art.

The immunogen/vaccine adjuvant composition of the invention can be administered to animals, e.g., mammals (human and non-human), fowl, and the like according to conventional methods well known to those skilled in the art (e.g., orally, subcutaneously, nasally, topically). It is preferred to administer the 1H-imidazo[4,5-c]quinolin-4-amine simultaneously with the immunogen (together in admixture or separately, e.g., orally or by separate injection) or subsequent to challenge with the immunogen. As seen in the Examples that follow (and as is common in the art) administration of the vaccine adjuvant prior to challenge with the immunogen can result in immunosuppression rather than stimulation.

The following Examples are provided to illustrate the invention.

In the Examples, "Compound A" designates 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine. "Compound B" designates 1-(2-hydroxy-2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine. "Compound C" designates 1-(2-hydroxy-2-methylpropyl)-2-methyl-1H-

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imidazo[4,5-c]quinolin-4-amine. "Compound D" designates 1-(2-hydroxy-2-methylpropyl)-2-ethoxymethyl-1H-imidazo[4,5-c]quinolin-4-amine.

5        STIMULATION OF <sup>3</sup>H-THYMIDINE UPTAKE IN CULTURES  
         OF HUMAN PERIPHERAL BLOOD MONONUCLEAR CELLS

         The test method described below demonstrates the ability of compounds to stimulate the uptake of <sup>3</sup>H-thymidine in human cells. Increased uptake of <sup>3</sup>H-thymidine indicates that the cells are actively  
10        dividing.

Blood Cell Preparation for Culture

         Whole blood is collected by venipuncture into  
15        heparin vacutainer tubes. Peripheral blood mononuclear cells (PBMC) are isolated using Ficoll-Paque® solution (available from Pharmacia LKB Biotechnology Inc., Piscataway, NJ). The PBMC are washed with Hank's Balanced Salts Solution then diluted with RPMI 1640  
20        medium containing 2.0 Mm L-glutamine, 10% fetal calf serum and 1% penicillin/streptomycin to obtain a concentration of  $2 \times 10^6$  cells/mL.

Compound preparation

25        The compounds are dissolved in water then diluted with the medium used above to give the desired concentration.

Incubation

30        A 0.1 mL portion of compound solution is added to the wells (3 wells for each treatment) of a 96 well round bottom tissue culture plate. Control wells receive 0.1 mL portions of medium. A 0.1 mL portion of cell suspension ( $1 \times 10^5$  cells) is added to each well  
35        and the plates are incubated for 48 hours at 37°C in the presence of 5% carbon dioxide. During the last 4 to

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6 hour of culture 1  $\mu\text{Ci}$  of  $^3\text{H}$ -thymidine (having a specific activity of 6.7 Ci/mole; available from New England Nuclear) is added to each well.

#### 5 $^3\text{H}$ -Thymidine Uptake Measurement/Analysis

Cultures are harvested and collected on glass fiber filter strips. Each strip is placed in a scintillation vial. A 1 to 2 mL portion of Aquasol®-2 Universal LSC Cocktail (available from DuPont) is added to each well. After 15 minutes the radioactivity is counted for 1 minute in a scintillation counter. A stimulation index (SI) is calculated by dividing the counts per minute from the treatment wells by the counts per minute from the control wells.

Results are shown in the table below. Concentrations are the final concentrations found in the well after the addition of the cell suspension. The CPM value is the mean CPM of the three wells for each treatment. Phytohemagglutinin (PHA) and lipopolysaccharide (LPS) are included as reference agents.

| STIMULATION OF $^3\text{H}$ -THYMIDINE UPTAKE IN CULTURES OF HUMAN PERIPHERAL BLOOD MONONUCLEAR CELLS |                    |      |
|---|--------------------|------|
| TREATMENT   | CPM $\pm$ SEM      | SI   |
| Medium  | 4,859 $\pm$ 392    | 1.0  |
| PHA (5 $\mu\text{g/mL}$ )   | 59,818 $\pm$ 2,867 | 12.3 |
| LPS (2 $\mu\text{g/mL}$ )   | 3,228 $\pm$ 433    | 0.7  |
| Compound C (4 $\mu\text{g/mL}$ )  | 30,119 $\pm$ 636   | 6.2  |
| Compound C (1 $\mu\text{g/mL}$ )  | 29,596 $\pm$ 3,221 | 6.1  |
| Compound C (0.25 $\mu\text{g/mL}$ )   | 43,055 $\pm$ 9,383 | 8.9  |
| Compound C (0.06 $\mu\text{g/mL}$ )   | 24,336 $\pm$ 2,756 | 5.0  |

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STIMULATION OF  $^3\text{H}$ -THYMIDINE UPTAKE  
BY MURINE SPLEEN CELLS

The test method described below demonstrates the ability of compounds to stimulate the uptake of  $^3\text{H}$ -thymidine by murine spleen cells. Increased uptake of  $^3\text{H}$ -thymidine indicates that the cells are actively dividing.

Spleen Cell Preparation for Culture

10 Spleens are aseptically removed from male CFW mice 4 to 8 weeks of age and placed in 10 mL of Hank's Balanced Salts Solution (HBSS). A scalpel is used to remove the cells from the capsule. A single cell suspension is prepared by pipetting the suspension  
15 several times using a 5.0 mL syringe equipped with a 19 gauge needle. The suspension is transferred to a 15 mL centrifuge tube and allowed to stand on ice for 4 minutes. The supernatant is removed with a 10 mL pipet, transferred to a clean 15 mL centrifuge tube and  
20 centrifuged at 1200 rpm for 5 to 10 minutes. The supernatant is discarded. To remove the red blood cells, the pellet is resuspended in 5 mL of 0.15M ammonium chloride, let stand at room temperature for 5 minutes and then centrifuged at 1200 rpm for 5 to 10  
25 minutes. The supernatant is discarded. The pellet is twice resuspended in 10 mL HBSS then centrifuged at 1200 rpm for 5 to 10 minutes. The supernatant is discarded. The pellet is resuspended in RPMI 1640 medium containing 2.0 mM L-glutamine, 10% fetal calf  
30 serum, 1% penicillin/streptomycin and  $5 \times 10^{-5}\text{M}$  2-mercaptoethanol. The cells are counted then diluted with medium to give a concentration of  $2 \times 10^6$  cells/mL.

Compound Preparation

35 The compounds are dissolved in water then diluted with medium to give the desired concentration.

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Incubation

The same procedures and conditions as described above for uptake in PBMC are used.

5 <sup>3</sup>H-Thymidine Uptake Measurement/Analysis

The same procedures and methods as described above for uptake in PBMC are used.

Results are shown in the table below.

Concentrations are the final concentrations found in  
10 the well after the addition of the cell suspension. The  
CPM value is the mean CPM of the three wells for each  
treatment. Concanavalin A (ConA), lipopolysaccharide  
(LPS), staphylococcal enterotoxin B (SEB) and  
polyriboinosinic acid-polyribocytidylic acid (Poly IC)  
15 are included as reference agents.

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| STIMULATION OF <sup>3</sup> H-THYMIDINE UPTAKE<br>BY MURINE SPLEEN CELLS |                   |         |      |
|--|-------------------|---------|------|
|  | TREATMENT         | CPM     | SI   |
|  | Medium            | 13,728  | 1.0  |
| 5  | ConA (5 μg/mL)    | 488,180 | 35.6 |
|  | LPS (5 μg/mL)     | 114,023 | 8.3  |
|  | SEB (1 μg/mL)     | 303,213 | 24.2 |
|  | Poly IC (5 μg/mL) | 36,102  | 2.6  |
|  |                   |         |      |
| 10   | <u>Compound</u>   |         |      |
|  | C (1 μg/mL)       | 161,573 | 11.8 |
|  | C (0.1 μg/mL)     | 147,356 | 10.7 |
|  | C (0.01 μg/mL)    | 67,960  | 5.0  |
|  | C (0.001 μg/mL)   | 20,004  | 1.4  |
| 15   | C (0.0001 μg/mL)  | 17,759  | 1.3  |
|  | A (1 μg/mL)       | 149,940 | 10.9 |
|  | A (0.1 μg/mL)     | 87,753  | 6.4  |
|  | A (0.01 μg/mL)    | 21,188  | 1.5  |
|  | A (0.001 μg/mL)   | 21,270  | 1.5  |
| 20   | B (1 μg/mL)       | 146,980 | 10.7 |
|  | B (0.1 μg/mL)     | 51,880  | 3.8  |
|  | B (0.01 μg/mL)    | 19,525  | 1.4  |
|  | B (0.001 μg/mL)   | 20,596  | 1.5  |
|  | B (0.0001 μg/mL)  | 22,076  | 1.6  |
| 25   | D (1 μg/mL)       | 174,203 | 12.7 |
|  | D (0.1 μg/mL)     | 165,630 | 12.1 |
|  | D (0.01 μg/mL)    | 180,606 | 13.2 |
|  | D (0.001 μg/mL)   | 116,380 | 8.5  |
|  | D (0.0001 μg/mL)  | 25,689  | 1.9  |

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STIMULATION OF ANTIBODY PRODUCTION  
IN MURINE SPLEEN CELLS

The test method described below demonstrates the ability of compounds to stimulate antibody production in murine spleen cells.

Spleen Cell Preparation for Culture

The spleen cells are prepared as described above except that they are diluted in 6 well tissue culture plates to give a final concentration of  $1 \times 10^7$  cells/mL.

Compound Preparation

The compounds are dissolved in water then diluted with medium to give the desired concentration.

Incubation

A 0.1 mL portion of compound solution is added to each well (2 wells for each treatment). Control wells receive medium. The final volume in the well is adjusted to 1 mL with medium. The plates are incubated for 72 hours at 37°C in the presence of 5% carbon dioxide.

Antibody Production Measurement/Analysis

Antibody production is measured by utilizing a modified Jerne Plaque Assay. Briefly stated, the method is as follows. Plastic culture dishes are coated with 2 mL of poly-L-lysine (50  $\mu$ g/mL). After 15 minutes the plates are washed with phosphate buffered saline (PBS) and 2 mL of washed sheep red blood cells (SRBC) diluted 1:20 in PBS is added. After 15 minutes the plates are swirled, allowed to settle for another 15 minutes and rinsed with buffered saline. Finally, 1.5 mL of phosphate-buffered saline, pH 7.2, is added to each plate along with  $2.5 \times 10^5$  spleen cells. The plates are

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then incubated in the presence of guinea pig complement at 37°C for 1 hour, after which plaque forming cells (PFC) are counted under slight magnification. Results are presented as the mean PFC/culture  $\pm$  SEM (standard error of the mean). A stimulation index (SI) is calculated by dividing the PFC from the treatment wells by the PFC from the control (medium) wells.

Results are shown in the table below.

Concentrations are the final concentrations found in the well after both the cell suspension and the compound solution have been added. The PFC value is the mean PFC of the 2 wells for each treatment group. Lipopolysaccharide (LPS) and polyribonucleic acid-polyribocytidylic acid (PIC) are included as reference agents.



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| STIMULATION OF ANTIBODY<br>PRODUCTION IN MURINE SPLEEN CELLS |             |     |                           |
|--|-------------|-----|---------------------------|
| TREATMENT  | PFC/Culture | SI  | PFC/10 <sup>6</sup> cells |
| Medium   | 167±18      | 1.0 | 30                        |
| 5 LPS (10 µg/mL)   | 1,555±208   | 9.3 | 179                       |
| LPS (3 µg/mL)  | 1,300±391   | 7.8 | 118                       |
| LPS (1 µg/mL)  | 1,150±232   | 6.9 | 153                       |
| PIC (10 µg/mL)   | 604±227     | 3.6 | 106                       |
| PIC (3 µg/mL)  | 365±142     | 2.2 | 49                        |
| 10 PIC (1 µg/mL)   | 273±15      | 1.6 | 29                        |
|  |             |     |                           |
| <u>Compound</u>  |             |     |                           |
| C (10 µg/mL)   | 1,419±219   | 8.5 | 121                       |
| C (3 µg/mL)  | 1,271±67    | 7.6 | 190                       |
| 15 C (1 µg/mL)   | 1,465±311   | 8.8 | 274                       |

#### STIMULATION OF B CELLS IN MURINE SPLEEN CELLS

20 The test method described below demonstrates the ability of compounds to stimulate B cells in murine spleen cells.

#### Spleen Cell Preparation for Culture

25 Spleen cells are prepared as described above in connection with the uptake of <sup>3</sup>H-thymidine.

#### Compound Preparation

The compounds are dissolved in water then diluted  
30 with medium to give the desired concentration.

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Incubation

A 0.9 mL portion of cell suspension is added to each well of a 12 well tissue culture plate. A 0.1 mL portion of compound solution is added to the wells (2 5 wells for each treatment). Control wells receive 0.1 mL portions of medium. The plates are incubated for 72 hours at 37°C in the presence of 5% carbon dioxide.

Quantitation of B and T Cells

10 The cell culture is removed from the well, combined with the culture from the second well, and washed twice with Hanks Balanced Salts Solution. The cells are diluted with phosphate buffered saline (PBS) supplemented with 1% fetal calf serum (FCS) to give a 15 concentration of  $1 \times 10^6$  cells/100  $\mu$ L. The cells are stained with antibody for 30 minutes at 4°C. Fluorescein isothiocyanate labeled goat anti-mouse immunoglobulin antibody (FITC  $\alpha$  Ig) functions as the B cell marker. Fluorescein isothiocyanate labeled anti 20 mouse Thy 1.2 antibody functions as the T cell marker. The cells are then washed twice with PBS supplemented with 1% FCS then analyzed for fluorescence using a Becton Dickinson FACSCAN. The results are reported as the percentage of the total cells, both the whole 25 (unseparated) cells and the blast-like cells, that are positive for the marker.

The results are shown in the table below. The concentrations are the final concentrations in the well after both the cell suspension and the compound 30 solution have been added. Lipopolysaccharide is included as a reference agent.

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| QUANTITATION OF B AND T CELLS IN<br>MURINE SPLEEN CELL CULTURES |                              |       |                      |       |
|---|------------------------------|-------|----------------------|-------|
| TREATMENT   | FITC $\alpha$ I <sub>G</sub> |       | FITC Anti<br>Thy 1.2 |       |
|   | Whole                        | Blast | Whole                | Blast |
| Medium  | 56.5                         | -     | 34.7                 | -     |
| LPS (5 $\mu$ g/mL)  | 73.1                         | 93.6  | 15.5                 | 9.4   |
|   |                              |       |                      |       |
| <u>Compound</u>   |                              |       |                      |       |
| C (4 $\mu$ g/mL)  | 72.3                         | 97.1  | 14.1                 | 10.7  |
| C (1 $\mu$ g/mL)  | 75.0                         | 97.0  | 14.1                 | 7.3   |
| C (0.25 $\mu$ g/mL)   | 74.0                         | 96.0  | 12.8                 | 9.9   |

#### ENHANCEMENT OF ANTIBODY FORMATION IN MICE

The test method described below demonstrates the ability of compounds to enhance antibody formation in mice to sheep red blood cells (a T-dependent antigen).

On day 0, male CFW mice 4 to 8 weeks of age are injected intraperitoneally with sheep red blood cells (1 X 10<sup>7</sup> in phosphate buffered saline). Also on day 0, test compounds are dissolved in sterile water then injected intraperitoneally (3 mice for each treatment). On day 4 the mice are sacrificed and the spleens are removed. Single cell suspensions are prepared in phosphate buffered saline to give a final concentration of 5 X 10<sup>5</sup> cells/mL for use in a modified Jerne Plaque Assay. The assay is performed as described above in connection with antibody formation in spleen cell cultures. The results are reported as plaque forming cells (PFC) per 10<sup>6</sup> cells and per spleen. A stimulation index (SI) is calculated by dividing the PFC value for

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the treatment group by the PFC value for the control (SRBC but no compound) group.

Results are shown in the table below. Values are the average number of plaque forming cells (PFC)  $\pm$  SEM. Each data point is the average of three mice pooled. Lipopolysaccharide (LPS) and polyribonucleic acid-polyribocytidylic acid (Poly IC) are included as reference agents.

10

| ENHANCEMENT OF ANTIBODY PRODUCTION IN MICE |                               |                |      |
|--|-------------------------------|----------------|------|
| TREATMENT                                  | PFC/<br>10 <sup>6</sup> CELLS | PFC/<br>SPLEEN | SI   |
| Saline                                     | 1                             | 11             |      |
| SRBC                                       | 7 $\pm$ 1                     | 473            | 1.0  |
| LPS (1 mg/Kg)<br>+ SRBC                    | 246 $\pm$ 24                  | 12,054         | 35.1 |
| Poly IC (100 $\mu$ g/Kg)<br>+ SRBC         | 74 $\pm$ 11                   | 5,180          | 10.5 |
| Compound C (10 mg/Kg)<br>+ SRBC            | 21 $\pm$ 2                    | 1,372          | 3.0  |
| Compound C (3 mg/Kg)<br>+ SRBC             | 82 $\pm$ 7                    | 6,123          | 11.7 |
| Compound C (1 mg/Kg)<br>+ SRBC             | 58 $\pm$ 7                    | 3,789          | 8.3  |

15

20

25

#### SUPPRESSION OF ANTIBODY FORMATION IN MICE

This test method is the same as the one described above for enhancement of antibody formation except that the compounds are administered on day minus 1 and 1 X 10<sup>8</sup> SRBC are administered on day 0. The percent suppression is calculated as follows:

30

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(PFC value of SRBC only - PFC value of treatment) X 100

PFC value of SRBC only

The results are shown in the table below.

|    |   |                               |                |               |
|----|---|-------------------------------|----------------|---------------|
| 5  | SUPPRESSION OF ANTIBODY FORMATION IN MICE |                               |                |               |
|    | TREATMENT                                 | PFC/<br>10 <sup>6</sup> CELLS | PFC/<br>SPLEEN | %<br>SUPPRESS |
|    | Saline                                    | 1±1                           | 38             | -             |
|    | SRBC                                      | 594±41                        | 34,000         | -             |
| 10 | Compound C (1 mg/Kg)<br>+ SRBC            | 129±16                        | 9,500          | 78.3          |
|    | Compound C (3 mg/Kg)<br>+ SRBC            | 87±8                          | 6,700          | 85.4          |
| 15 | Compound C (1 mg/Kg)<br>+ saline day 0    | 3±1                           | 220            | -             |

The experiments set forth below illustrate the adjuvant effect in guinea pigs of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine used in connection with a herpes simplex 2 (HSV-2) glycoprotein subunit vaccine.

#### HSV-2 glycoprotein preparation

HSV-2 (strain MS) infected Vero cells were solubilized and the glycoproteins were purified by lentil-lectin sepharose chromatography. The final preparation contained all three HSV-2 glycoproteins, gB, gD, and gG, that were evaluated. The glycoprotein preparation was diluted to contain 35 µg/0.1 mL total glycoprotein. Glycoprotein administration is described below in connection with the experimental design.

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Treatment Groups

1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine (one percent by weight in a cream containing water (76.5%), isosteric acid (10%), stearyl alcohol (3.1%), polysorbate 60 (2.55%), cetyl alcohol (2.2%), benzyl alcohol (2%), glycerin (2%), sorbitan monostearate (0.45%), methylparaben (0.2%), and propylparaben (0.02%) was administered to guinea pigs as described below intravaginally at a concentration of 5 mg/kg/day for 5 days beginning either simultaneously with glycoprotein administration ("S group"), or after a delay of 48h after glycoprotein administration ("D group"). The hydrochloride salt was administered in water subcutaneously at a dose of 3 mg/kg/day for 5 days beginning simultaneously with glycoprotein administration ("subQ S group"). Complete Freund's adjuvant ("CFA", Sigma) was administered as a 1:1 mixture of the adjuvant and the glycoprotein ("CFA Group"). An unimmunized infected control group was maintained. Also one group was given the glycoprotein alone ("glycoprotein group").

Experimental design

Hartley female guinea pigs (Charles River Breeding Laboratory, Wilmington, Mass.) weighing 200-300 g were immunized with 35  $\mu$ g of HSV-2 glycoproteins in the hind footpads, first 35 days prior to vaginal inoculation with HSV-2 and again 14 days prior to inoculation.

Animals were inoculated intravaginally with  $10^{5.7}$  pfu of either 333 strain HSV-2 (first experiment) or MS strain (ATCC VR-540) HSV-2 (second experiment). Samples of vaginal secretions were then collected over the next 10 days and stored frozen at -70°C prior to assay on Vero cells for viral concentration. During the acute infection period (days 1-14), animals were evaluated daily for genital skin disease which was quantitated on a scale of 0-4 as described in J. Infect. Dis., 1982,

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146, 397 (Stanberry et al.). Total lesion scores are the sum of these scores for days 1 through 14. After recovery from the acute infection, animals were examined daily from day 15-60 for evidence of recurrent  
5 herpetic disease. Sera were collected from immunized animals just prior to intravaginal inoculation and again 14, 44, or 60 days later.

#### Enzyme-linked immunosorbent assay for HSV-2 antibodies

10 HSV-2 antibodies were quantified by an ELISA assay. Lectin purified HSV-2 glycoproteins were used as the solid phase and peroxidase-conjugated rabbit anti-guinea pig immunoglobulins (Accurate Chemical, Westbury, N.Y.) were used for detection of guinea pig  
15 antibody. Absorbances were compared to a standardized control serum arbitrarily assigned a value of 10,000 ELISA units.

#### Statistics

20 Comparison of lesion scores for acute disease, viral shedding, and recurrent lesion days were done by two-tailed ANOVA with the Bonferroni correction to adjust for multiple groups. Data are expressed as mean  $\pm$  S.E.

25

#### Acute Disease

To determine if 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine would increase the effectiveness of an HSV-2 glycoprotein vaccine, five treatment groups of  
30 11 guinea pigs were used as follows:

- 1) unimmunized control group;
- 2) glycoprotein group;
- 3) D Group;
- 4) S Group; and
- 35 5) CFA Group.

Immunization with the HSV-2 glycoproteins alone significantly reduced the total lesion score from

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19.1  $\pm$  3.2 in the unimmunized control group to  
3.9  $\pm$  0.9 ( $p < .001$ ). Because of the mild disease in the  
glycoprotein group, no further significant reduction  
could be demonstrated for the other groups, although  
5 the total lesion score was less for each of the groups  
receiving a vaccine adjuvant treatment. (D group,  
2.8  $\pm$  0.7; S Group, 2.2  $\pm$  0.6; CFA Group, 1.2  $\pm$  0.5).

Immunization with glycoprotein alone and also with  
the several adjuvant preparations reduced vaginal viral  
10 shedding compared to the unimmunized infected control  
group.

#### Recurrent Disease

The recurrence pattern was similar for the  
15 unimmunized control group and glycoprotein group  
(4.9  $\pm$  0.9 vs. 4.3  $\pm$  0.9 recurrent lesion days,  
respectively). The use of 1-(2-methylpropyl)-1H-  
imidazo[4,5-c]quinolin-4-amine as an adjuvant, however,  
significantly reduced recurrent lesion days to  
20 0.8  $\pm$  0.3 and 0.1  $\pm$  0.1, respectively, for the S Group  
and D Group ( $p < .01$  for each compared to the  
glycoprotein group). Only one of ten animals in the S  
Group developed a recurrence, while eight of nine  
recipients of glycoprotein alone ( $p < .002$ ) developed a  
25 recurrence. Three of ten animals in the CFA Group  
developed recurrent lesions.

#### Antibody Response

Compared to the glycoprotein group, antibody  
30 titers on the day of inoculation were marginally  
increased in the S Group ( $p < .05$ ), but increased by over  
tenfold in the CFA Group ( $p < .001$ ). Peak antibody titers  
(day 44) in the unimmunized infected control group  
approached the level induced in the glycoprotein group.  
35 The CFA Group titers were higher than the unimmunized  
control group and the groups receiving 1-(2-



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methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine as a vaccine adjuvant.

The experiment described above was repeated, with the addition of two treatment groups, in order to examine the effects of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine given subcutaneously with glycoprotein ("SubQ S Group"), and the effects of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine alone ("Compound Group").

A pool of HSV-2 MS strain that had previously produced milder acute disease but more frequent recurrences was used in order to better observe effects on recurrent disease.

#### Acute Disease

The only groups to develop lesions acutely were the unimmunized groups (Compound Group, 9 of 9; unimmunized control group, 11 of 11) and the glycoprotein group (6 of 11). Again, because of the significant effect of immunization with glycoprotein alone, only small adjuvant effects of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine on the severity of the acute disease could be demonstrated (differences in total lesion score ( $p < .05$ ) for each compared to glycoprotein alone).

Vaginal viral shedding was also decreased by immunization with glycoprotein alone. The use of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine as an adjuvant, however, further decreased viral shedding. Compared to glycoprotein alone, viral shedding was decreased tenfold in the D Group, by another tenfold in the S Group ( $p < .05$ ), and by yet another tenfold in the SubQ S Group ( $p < .001$ ) on day one. Thus, there was >99.9% reduction in the SubQ S Group compared to the glycoprotein group and a >99.9% reduction compared to the unimmunized control group. No virus was detected in

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the CFA group. Treatment with 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine alone had no significant effect on vaginal viral shedding.

#### 5 Recurrent Disease

Results are shown in the Table below:

| EFFECT OF ADJUVANT ON THE PATTERN OF<br>RECURRENT GENITAL HSV-2 DISEASE |                                      |   |
|---|--------------------------------------|---|
| Group   | Animals with<br>recurrent<br>lesions | No. days with<br>herpetic<br>lesions <sup>a</sup> |
| Unimmunized control   | 11/11                                | 5.7 ± 0.8   |
| Glycoprotein  | 9/11                                 | 2.5 ± 0.9 <sup>c</sup>                            |
| D Group   | 4/11                                 | 0.4 ± 0.2 <sup>b</sup>                            |
| S Group   | 3/11 <sup>b</sup>                    | 0.3 ± 0.1 <sup>b</sup>                            |
| SubQ S Group  | 0/11 <sup>c</sup>                    | 0 <sup>d</sup>                                    |
| CFA Group   | 0/11 <sup>c</sup>                    | 0 <sup>d</sup>                                    |
| Compound Group  | 8/11                                 | 1.8 ± 0.5   |

20

- <sup>a</sup> Mean ± SE per animal of days with recurrent herpetic lesions  
<sup>b</sup> P<.05 compared to Glycoprotein group  
<sup>c</sup> P<.001 compared to Glycoprotein group  
<sup>d</sup> P<.01 compared to Glycoprotein group  
<sup>e</sup> P<.001 compared to unimmunized control

25

30 Immunization with the glycoproteins alone significantly reduced recurrent lesion days compared to unimmunized controls (p<.01), but not the number of animals with recurrences. Compared to the glycoprotein alone, however, the use of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine as an adjuvant further

35

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significantly reduced recurrent lesion days and reduced the number of animals with recurrences. None of the animals in the SubQ S Group developed recurrences ( $p < .001$  compared to glycoprotein alone). The Compound 5 Group also developed significantly fewer recurrences than the unimmunized control group ( $p < .001$ ).

#### Antibody Response

Antibody titers in the CFA group were again over 10 tenfold higher than the glycoprotein group ( $p < .001$ ) and the D Group, S Group, and SubQ S Group ( $p < .01$ ). Groups that received 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine as an adjuvant did not, however, develop higher titers of HSV-2 antibody than the 15 glycoprotein group. The Compound Group developed higher antibody titers than the unimmunized control group ( $p < .05$ ).

The results above indicate that 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine 20 augments the ability of the HSV-2 glycoprotein vaccine to decrease viral replication at the mucosal site, prevent clinical disease, and decrease the number of recurrences that develop after infection.

The most effective regimen involved subcutaneous 25 administration for 5 doses beginning at the time of immunization. The results were comparable to using CFA as an adjuvant. Animals that received intravaginal administration had decreased viral titers and fewer recurrent lesion days.

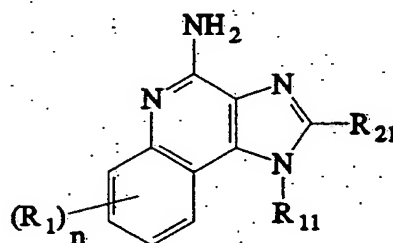
30 The addition of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine to glycoprotein immunization had little effect on antibody titers but significantly increased the protection provided by the glycoprotein preparation especially against recurrent disease.

35

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The claimed invention is:

1. An immunogen/vaccine adjuvant composition comprising an immunogen in an amount effective to stimulate an immune response and as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune response to the immunogen.
2. An immunogen/vaccine adjuvant composition according to Claim 1, wherein the 1H-imidazo[4,5-c]quinolin-4-amine is a compound defined by one of Formulas I-V:



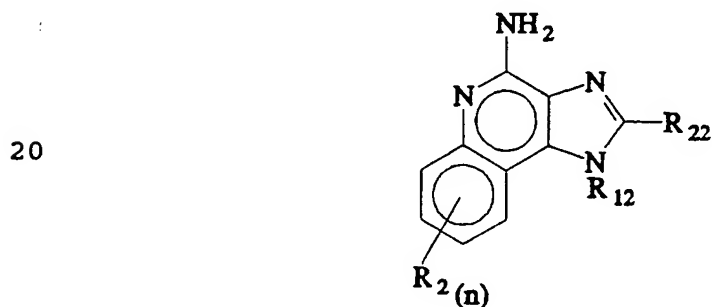
I

wherein

R<sub>11</sub> is selected from the group consisting of alkyl, hydroxyalkyl, acyloxyalkyl, benzyl, (phenyl)ethyl and phenyl, said benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen, with the proviso that if said benzene ring is substituted by two of said moieties, then said moieties together contain no more than 6 carbon atoms; R<sub>21</sub> is selected from the group consisting of hydrogen,

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alkyl of one to about eight carbon atoms, benzyl, (phenyl)ethyl, and phenyl, the benzyl (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently  
 5 selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen, with the proviso that when the benzene ring is substituted by two of said  
 moieties, then the moieties together contain no more  
 10 than 6 carbon atoms; and each  $R_1$  is independently selected from the group consisting of alkoxy of one to about four carbon atoms, halogen, and alkyl of one to about four carbon atoms, and  $n$  is an integer from 0 to 2, with the proviso that if  $n$  is 2, then said  $R_1$  groups  
 15 together contain no more than 6 carbon atoms;



25

II

wherein

$\text{R}_{12}$  is selected from the group consisting of  
 30 straight chain or branched chain alkenyl containing 2 to about 10 carbon atoms and substituted straight chain or branched chain alkenyl containing 2 to about 10 carbon atoms, wherein the substituent is selected from the group consisting of straight chain or branched  
 35 chain alkyl containing 1 to about 4 carbon atoms and cycloalkyl containing 3 to about 6 carbon atoms; and

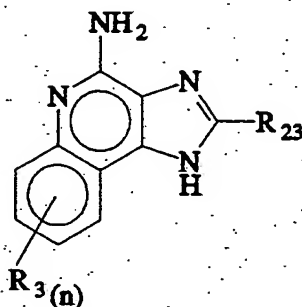
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cycloalkyl containing 3 to about 6 carbon atoms substituted by straight chain or branched chain alkyl containing 1 to about 4 carbon atoms; and

$R_{22}$  is selected from the group consisting of  
5 hydrogen, straight chain or branched chain alkyl containing one to about eight carbon atoms, benzyl, (phenyl)ethyl and phenyl, the benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently  
10 selected from the group consisting of straight chain or branched chain alkyl containing one to about four carbon atoms, straight chain or branched chain alkoxy containing one to about four carbon atoms, and halogen, with the proviso that when the benzene ring is  
15 substituted by two such moieties, then the moieties together contain no more than 6 carbon atoms; and  
each  $R_2$  is independently selected from the group consisting of straight chain or branched chain alkoxy containing one to about four carbon atoms, halogen, and  
20 straight chain or branched chain alkyl containing one to about four carbon atoms, and  $n$  is an integer from zero to 2, with the proviso that if  $n$  is 2, then said  $R_2$  groups together contain no more than 6 carbon atoms;

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30



III

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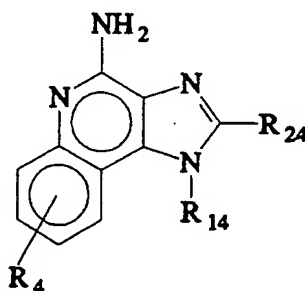
- 37 -

wherein

$R_{23}$  is selected from the group consisting of hydrogen, straight chain or branched chain alkyl of one to about eight carbon atoms, benzyl, (phenyl)ethyl and phenyl, the benzyl, (phenyl)ethyl or phenyl substituent being optionally substituted on the benzene ring by one or two moieties independently selected from the group consisting of straight chain or branched chain alkyl of one to about four carbon atoms, straight chain or branched chain alkoxy of one to about four carbon atoms, and halogen, with the proviso that when the benzene ring is substituted by two such moieties, then the moieties together contain no more than 6 carbon atoms; and

each  $R_3$  is independently selected from the group consisting of straight chain or branched chain alkoxy of one to about four carbon atoms, halogen, and straight chain or branched chain alkyl of one to about four carbon atoms, and  $n$  is an integer from zero to 2, with the proviso that if  $n$  is 2, then said  $R$  groups together contain no more than 6 carbon atoms;

25



30

IV

wherein  $R_{14}$  is  $-CHR_A R_B$

- 38 -

wherein

$R_B$  is hydrogen or a carbon-carbon bond, with the proviso that when  $R_B$  is hydrogen  $R_A$  is alkoxy of one to about four carbon atoms, hydroxyalkoxy of one to about four carbon atoms, 1-alkynyl of two to about ten carbon atoms, tetrahydropyranyl, alkoxyalkyl wherein the alkoxy moiety contains one to about four carbon atoms and the alkyl moiety contains one to about four carbon atoms, 2-, 3-, or 4-pyridyl, and with the further

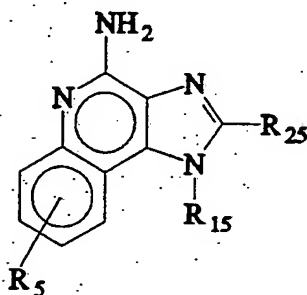
10 proviso that when  $R_B$  is a carbon-carbon bond  $R_B$  and  $R_A$  together form a tetrahydrofuranyl group optionally substituted with one or more substituents independently selected from the group consisting of hydroxy and hydroxyalkyl of one to about four carbon atoms;

15  $R_{24}$  is selected from the group consisting of hydrogen, alkyl of one to about four carbon atoms, phenyl, and substituted phenyl wherein the substituent is selected from the group consisting of alkyl of one to about four carbon atoms, alkoxy of one to about four carbon atoms, and halogen; and

20

$R_4$  is selected from the group consisting of hydrogen, straight chain or branched chain alkoxy containing one to about four carbon atoms, halogen, and straight chain or branched chain alkyl containing one

25 to about four carbon atoms;





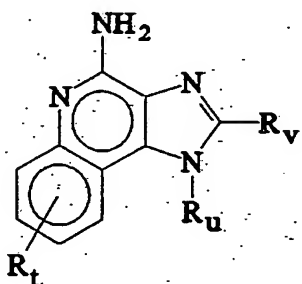
- 39 -

wherein

- $R_{15}$  is selected from the group consisting of:  
hydrogen; straight chain or branched chain alkyl  
containing one to about ten carbon atoms and  
5 substituted straight chain or branched chain alkyl  
containing one to about ten carbon atoms, wherein the  
substituent is selected from the group consisting of  
cycloalkyl containing three to about six carbon atoms  
and cycloalkyl containing three to about six carbon  
10 atoms substituted by straight chain or branched chain  
alkyl containing one to about four carbon atoms;  
straight chain or branched chain alkenyl containing two  
to about ten carbon atoms and substituted straight  
chain or branched chain alkenyl containing two to about  
15 ten carbon atoms, wherein the substituent is selected  
from the group consisting of cycloalkyl containing  
three to about six carbon atoms and cycloalkyl  
containing three to about six carbon atoms substituted  
by straight chain or branched chain alkyl containing  
20 one to about four carbon atoms; hydroxyalkyl of one to  
about six carbon atoms; alkoxyalkyl wherein the alkoxy  
moiety contains one to about four carbon atoms and the  
alkyl moiety contains one to about six carbon atoms;  
acyloxyalkyl wherein the acyloxy moiety is alkanoyloxy  
25 of two to about four carbon atoms or benzoyloxy, and  
the alkyl moiety contains one to about six carbon  
atoms; benzyl; (phenyl)ethyl; and phenyl; said benzyl,  
(phenyl)ethyl or phenyl substituent being optionally  
substituted on the benzene ring by one or two moieties  
30 independently selected from the group consisting of  
alkyl of one to about four carbon atoms, alkoxy of one  
to about four carbon atoms, and halogen, with the  
proviso that when said benzene ring is substituted by  
two of said moieties, then the moieties together  
35 contain no more than six carbon atoms; or a  
pharmaceutically acceptable salt thereof.

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3. A composition according to Claim 1, wherein the 1H-imidazo[4,5-c] quinolin-4-amine is a compound of Formula VI:



VI

15 wherein

R<sub>t</sub> is selected from the group consisting of hydrogen, straight chain or branched chain alkoxy containing one to about four carbon atoms, halogen, and straight chain or branched chain alkyl containing one to about four carbon atoms;

R<sub>u</sub> is 2-methylpropyl or 2-hydroxy-2-methylpropyl; and

R<sub>v</sub> is hydrogen, alkyl of one to about six carbon atoms, or alkoxyalkyl wherein the alkoxy moiety contains one to about four carbon atoms and the alkyl moiety contains one to about four carbon atoms.

4. A composition according to Claim 3, wherein R<sub>t</sub> is hydrogen.

5. A composition according to Claim 3, wherein R<sub>t</sub> is hydrogen, R<sub>u</sub> is 2-methylpropyl or 2-hydroxy-2-methylpropyl, and R<sub>v</sub> is hydrogen, methyl, or ethoxymethyl.

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6. A composition according to Claim 1, wherein the compound is selected from the group consisting of 1-(2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine; 1-(2-hydroxy-2-methylpropyl)-1H-imidazo[4,5-c]quinolin-4-amine; 1-(2-hydroxy-2-methylpropyl)-2-methyl-1H-imidazo[4,5-c]quinolin-4-amine; and 1-(2-hydroxy-2-methylpropyl)-2-ethoxymethyl-1H-imidazo[4,5-c]quinolin-4-amine.

7. A composition according to Claim 1, wherein the immunogen is selected from the group consisting of a live viral immunogen, a live bacterial immunogen, an inactivated viral immunogen, an inactivated tumor-derived immunogen, an inactivated protozoal immunogen, an inactivated organism-derived immunogen, an inactivated fungal immunogen, an inactivated bacterial immunogen, a toxoid, a toxin, a polysaccharide, a protein, a glycoprotein, and a peptide.

8. A composition according to Claim 1, wherein the immunogen is a conventional vaccine preparation.

9. A composition according to Claim 1, wherein the immunogen is a recombinant subunit vaccine.

10. A composition according to Claim 1, wherein the immunogen is a T-dependent immunogen.

11. A composition according to Claim 1, wherein the immunogen is a herpes simplex 2 immunogen.

12. A composition according to Claim 1, wherein the immunogen is herpes simplex 2 glycoprotein subunit preparation.

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13. A composition according to Claim 1, comprising an admixture of the 1H-imidazo[4,5-c]quinolin-4-amine and the immunogen in a pharmaceutically acceptable carrier.

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14. A composition according to Claim 1 in the form of a kit comprising (i) an adjuvant component comprising the 1H-imidazo[4,5-c]quinolin-4-amine, and (ii) an immunogen component separate from the adjuvant  
10 component and comprising the immunogen.

15. A method of increasing the immune response to an immunogen, comprising the step of administering (i) the immunogen in an amount effective to stimulate an  
15 immune response, and (ii) as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune response.

16. A method of increasing the immune response of  
20 a mammal to an immunogen, comprising the step of administering to the mammal (i) the immunogen in an amount effective to stimulate an immune response, and (ii) as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune  
25 response.

17. A method of increasing the immune response of a fowl to an immunogen, comprising the step of administering to the fowl (i) the immunogen in an  
30 amount effective to stimulate an immune response, and (ii) as a vaccine adjuvant a 1H-imidazo[4,5-c]quinolin-4-amine in an amount effective to increase the immune response.

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/03295

|  |  |                                     |
|--|--|-------------------------------------|
| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>  |  |                                     |
| According to International Patent Classification (IPC) or to both National Classification and IPC  |  |                                     |
| Int.Cl. 5 A61K39/39  |  |                                     |
| <b>II. FIELDS SEARCHED</b>   |  |                                     |
| Minimum Documentation Searched?  |  |                                     |
| Classification System  | Classification Symbols   |                                     |
| Int.Cl. 5  | A61K   |                                     |
| Documentation Searched other than Minimum Documentation<br>to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>  |  |                                     |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>  |  |                                     |
| Category <sup>10</sup>   | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>   | Relevant to Claim No. <sup>13</sup> |
| X,P  | THE JOURNAL OF INFECTIOUS DISEASES<br>vol. 167, no. 3, March 1993,<br>pages 731 - 735<br>DAVID I. BERNSTEIN ET AL. 'ADJUVANT<br>EFFECTS OF IMIQUIMOD ON A HERPES SIMPLEX<br>VIRUS TYPE 2 GLYCOPROTEIN VACCINE IN<br>GUINEA PIGS.'<br>THE WHOLE ARTICLE | 1-17                                |
| Y  | ANTIVIRAL RESEARCH<br>vol. 10, 1988,<br>pages 209 - 223<br>C.J. HARRISON ET AL.<br>THE WHOLE ARTICLE   | 1-7, 11,<br>13, 14                  |
|  | ---  |                                     |
|  | ---  |                                     |
|  | -/--   |                                     |
| <sup>10</sup> Special categories of cited documents :<br>"A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier document but published on or after the international filing date<br>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"P" document published prior to the international filing date but later than the priority date claimed<br>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention<br>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step<br>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.<br>"A" document member of the same patent family |  |                                     |
| <b>IV. CERTIFICATION</b>   |  |                                     |
| Date of the Actual Completion of the International Search  | Date of Mailing of this International Search Report  |                                     |
| 09 AUGUST 1993   | 24 -08- 1993   |                                     |
| International Searching Authority  | Signature of Authorized Officer  |                                     |
| EUROPEAN PATENT OFFICE   | REMPP G.L.E.   |                                     |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) |  |                       |
|--|--|-----------------------|
| Category *   | Citation of Document, with indication, where appropriate, of the relevant passages   | Relevant to Claim No. |
| Y  | ANTIMICROBIAL AGENTS AND CHEMOTHERAPY.<br>vol. 33, no. 9, September 1989,<br>pages 1511 - 1515<br>DAVID I. BERNSTEIN ET AL.<br>THE WHOLE ARTICLE<br>---- | 1-7, 11,<br>13, 14    |
| Y  | EP,A,0 389 302 (RIKER LABORATORIES, INC.)<br>26 September 1990<br>cited in the application<br>see page 8, line 57 - page 10, line 31<br>----             | 1-17                  |
| Y  | EP,A,0 145 340 (RIKER LABORATORIES, INC.)<br>19 June 1985<br>cited in the application<br>see page 15, line 28 - page 18, line 20<br>----                 | 1-17                  |
| Y  | EP,A,0 385 630 (RIKER LABORATORIES)<br>5 September 1990<br>cited in the application<br>see page 8, line 23 - page 10, line 13<br>-----                   | 1-17                  |

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 93/03295

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
Remark: Although claims 15-17 are directed to a method of treatment of (diagnostic method practised on) the human/animal body the search has been carried out and based on the alleged effects of the compound/ composition.
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

US 9303295  
SA 73017

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09/08/93

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
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|   |                     | JP-A- 3027381              | 05-02-91            |
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